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AUTHOR Avery, Chris; And Others
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ABSTRACT

An overview is provided of De Anza College's use of computerized instruction in its mathematics courses. After reviewing the ways in which computer technology is changing math instruction, the paper looks at the use of computers in several course sequences. The instructional model for the algebra sequence is based on a large group format of lectures supported by closely monitored laboratories, in which the computer acts as tutor and skill builder. The software for the calculus sequence allows students to picture relationships quickly using the hi-resolution graphics of the Apple computer, which can numerically perform concepts such as limits, differentiation, and integration at the touch of a key. The microcomputer lab supports both engineering calculus, which employs an open lab format to explore the ideas of calculus in a graphical intuitive as well as numerical setting; and business calculus, which employs a series of lab assignments on supply and demand, consumer surplus, annuities, and other problems of economics and finance. The software for the statistics course goes beyond the concepts of skills and tools to place the students in a simulated environment with a number of analytical and simulation methods at their disposal. Attachments include a list of current software titles, student information and typical lab assignments for intermediate algebra and a sample of calculus lab assignments. (AYC)

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A MICROCOMPUTER LAB
FOR
ALGEBRA & CALCULUS

by

Chris Avery Chris Barker Frank Soler

De Anza College
21250 Stevens Creek Blvd.
Cupertino, CA, 95014
(408) 996 - 4774

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COMPUTER ASSISTED INSTRUCTION IN MATHEMATICS

BY

CHRIS AVERY CHRIS BARKER FRANK SOLER

MATHEMATICS DEPARTMENT
DE ANZA COLLEGE
CUPERTINO, CA.

1.0 Introduction

We are on the verge of a tremendous revolution in mathematics. The revolution centers on the computer as a mathematical tool of intrinsic fundamental value. Computers are very much changing the way we think about mathematics, the way we practice mathematics, the way we learn mathematics, and most importantly, the way we teach mathematics.

Computers allow for the modeling of mathematical situations previously thought beyond the mathematical maturity of our students. It reaches area beyond the reach of human calculation and it allows for the exploration of mathematics previously considered untractable or impractical.

The full impact of the computer revolution in mathematics education may not be realized for some time, but even today we are allowed some glimpses of futuristic dimensions.

The intent of this brief paper is to review the achievements of computerized instruction in mathematics at De Anza College and at the same time browse through projects, already underway, that will continue to challenge the more traditional approaches in mathematics education.

2.0 The Algebra Sequence

The computer aided model for pre-algebra, beginning algebra, and intermediate algebra courses are based on a large group format. Lectures of 120 students are supported by closely monitored laboratories. The computer in the lab is utilized in the role of tutor and skill builder. An instructor and aid are at hand to provide personal assistance when needed. In the lab, the student becomes an active participant in the learning process. Feedback becomes the rule rather than the exception. Students continuously interact with the software, with each other and with the instructor. A positive on-disk grading system encourages students to rework problem sets until a score of 100% is achieved. Mastery learning becomes a reality for students in this model. By and large, students in this format develop more consistent study habits as compared to their peers in the traditional instructional modes.

Skill building has proved a very effective method for our pre-algebra, algebra students. There is a 50% increase in the productivity of the instructor using this format. At the same time, attrition which is often between 40% and 50% was greatly reduced. Best of all, student attitudes toward mathematics changed in a positive way as they took a more active roll in their education. Still, the potential for computers in education goes far beyond skill building.

The exploratory capabilities of the computer promise to change our traditional view of mathematical education. Using computer graphics and numerical routines, our students will be able to explore the mathematical landscape in ways not before possible. We can offer our students a comprehensive view of the mathematical forest without being lost on individual trees. It is precisely this stage of development that is taking place in the calculus sequences.

3.0 The Calculus Sequence

The software for the calclulus student is a mathematical tool much like a word processor is a tool for writers. With this software, the student is able to picture relationships quickly using the hi-resolution graphics of the Apple computer. Beyond that, concepts such as limits, differentiation, and integration are performed numerically at the touch of a key. The student is not tied to the traditional algebraic process. A specific answer to a problem is found and at the same time the significance of the problem is demonstrated graphically.

3.1 Engineering Calculus Sequence

A series of laboratory assignments have been designed to provide a foundation from which the students may begin to explore the ideas of calculus in a graphical, intuitive as well as numerical setting. Algebraic derivations and rigor are not bypassed. On the contrary, where appropriate, algebraic manipulations are used to verify numerical and intuitive results. Such calculations that verify existing data are more meaningful than standard textbook exercises.

An open lab format is used in the calculus sequence. In this setting, the basic concepts of calculus are not just "learned", they are explored. The student has personal experience with the power of the methods being learned in the classroom.

The calculus software is also used as a classroom aid to demonstrate difficult concepts. Using the computer monitor in place of the blackboard provides a fresh approach to the traditional lecture.

3.2 Business Calculus

The calculus software has proven effective for our business oriented students. The format is the same with a series of lab assignments tailored to their particular needs. Problems dealing with supply and demand, consumer surplus, and annuities can be handled by students who have minimal mathematical backgrounds. They quickly begin to see a relation between the subject of calculus and problems of economics and finance.

4.0 Elementary Statistics

The software for the Statistics course goes beyond the concepts of skills and tools. The Statistics project is intended to place the students in a completely simulated environment with a number of analytical and simulation methods at their disposal. This is an environment where the students may analyze data and make decisions based on the results of such analysis. It is also an environment where the students may quickly and efficiently attempt different approaches with a given data set. The concepts of risk, cost estimation, and probability will quickly come together to provide a sound statistical experience much different from the typical textbook situation.

The software is being used for the first time with a test group of 40 students. It will be ready for full implementation by Fall 1986.

5.0 Conclusion

The De Anza program in computer aided instruction in mathematics centers around three conceptual models.

First and fundamental is the concept of skill building. Using this model, more students are able to master given skills in a shorter time than their traditional counterparts. The gain in efficiency allows the classroom teacher to deal effectively with larger numbers of students.

Second is the model which uses the computer as a mathematical tool. Such use allows the student to explore many more areas than the traditional student who is forced to deal with canned and artificial problems.

Third is the simulation model. In this model, concepts impossible to experience in reality can be readily explored by the student. A course like statistics takes on a new meaning for the average student.

6.0 Attachments

Current software titles

Student information for intermediate algebra

Typical lab assignments for intermediate algebra

Sample of calculus lab assignments

Software programs currently used in the De Anza College computer aided mathematics program.

PRE - ALGEBRA COMPUTER LAB

1 = Whole numbers - add and subtract
2 = Whole numbers - multiply and divide
3 = Whole numbers - mixed operations
4 = Exponents and whole numbers
5 = Factors of whole numbers
6 = Cancellation property for fractions
7 = Fractions - multiply and divide
8 = Fractions - add and subtract
9 = Operations with mixed numbers
10 = Equations and proportions
11 = Decimals and fractions
12 = Percents; decimals; fractions
13 = Basic word problems
14 = Integers - add and subtract
15 = Integers - mixed operations
16 = Formulas

BEGINNING ALGEBRA COMPUTER LAB

1 = Exponents and integers
2 = Combining like terms
3 = Distributive rule
4 = First degree equations
5 = Rules of exponents
6 = Binomial products
7 = Factoring trinomial expressions
8 = Second degree equations
9 = Least common multiple
10 = Building fractions
11 = Addition of rational expressions
12 = Equations with rational expressions
13 = Linear equations in x and y
14 = Slopes and equations of lines
15 = Intersection of lines
16 = Simplification of square roots
17 = Products and quotients of square roots
18 = Equations with square roots
19 = Completing the square

INTERMEDIATE ALGEBRA COMPUTER LAB

1 = Linear equations
2 = Linear inequalities
3 = Absolute value problems
4 = Factoring polynomials
5 = Quadratic equations and inequalities
6 = Division of polynomials
7 = Addition of rational expressions
8 = Rules of exponents
9 = Equations with rational expressions
10 = Rational exponents
11 = Equations with rational exponents
12 = Square root products and sums
13 = Completing the square
14 = Slopes and equations of lines
15 = Intersection and inequalities
16 = Conic sections
17 = Exponents & logarithmic functions
18 = Exponential & logarithmic equations
19 = Sequences

COMPUTER LAB FOR CALCULUS

1 = Function plotter
2 = Parametric equation plotter
3 = Parametric equations, 3 dimensions
4 = Polar equation plotter
5 = Implicit function plotter
6 = Riemann sums
7 = Numerical integration
8 = Double integration
9 = Triple integration
10 = Exponents & logs (1)
11 = Exponents & logs (2)
12 = Sequences & series
13 = Surface plotter, z = f(x,y)
14 = First order differential equation

Sample information sheet for intermediate algebra

Math 50 GENERAL INFORMATION Fall 1985

Prerequisite: Passing grade in Math 81 or equivalent

Text: INTERMEDIATE ALGEBRA FOR COLLEGE STUDENTS -
Karl Smith & Patrick Boyle 3rd edition

Disk: Intermediate Algebra - Avery/Barker

Instructor: Chris Avery E21b 996-4726

Office Hours: Mon.-Thurs. 11:30 to 12:30 E21b, or
Daily 7:30 to 8:20 S81

Exams: Three one-hour exams will be given. There will be no makeups.

Quizzes: Spot quizzes on homework will be given frequently. There will be no makeups for missed quizzes.

Laboratory: A one- hour computer lab is scheduled twice a week to reinforce concepts learned in lecture. The Apple IIe lab is located in S81. Computer Lab participation will be counted as part of your grade. Lab assignments may be done on home computers.

There is no eating, drinking or smoking allowed in the lab.

Attendance: Regular attendance is necessary to understand the material. 12 points are given for attendance. 2 points are deducted for each absence from the lecture.

Important Dates:

10/4	Last day to drop without fee
10/18	Last day to drop with no grade on record
10/22	Last day to drop with a "W"

Final Exam: A two-hour comprehensive final exam will be given on Mon., Dec. 16, 9:45 to 11:45. A student who misses the final exam and does not contact the instructor will receive an F in the course.

Grade:

3 one-hour exams	300	A: 90 - 100%
Quizzes	100	B: 80 - 89%
Lab	100	C: 65 - 79%
Final Exam	200	D: 50 - 64%
		F: 0 - 49%
Total	600	

The final is worth 100 points and is counted twice. You then have 7 100-point scores. The lowest 100 point score will be discounted.

Sample computer assignments for intermediate algebra

Math 50 Computer Lab Assignments Name _____ Lab 1 2 3

Date	Program	Level: 1	2	3	Score	Score
9/26	1 Linear Equations	2	2	2	_____	_____
	2 Linear Inequalities	2	2	2	_____	_____
10/1	3 Absolute Value Problems	4	4	4	_____	_____
10/3	14 Slopes and Equations of Lines	4	4	4	_____	_____
10/8	4 Factoring Polynomials	4	-	4	_____	_____
	5 Quadratic Equations & inequalities	-	4	4	_____	_____
10/10	7 Addition of Rational Expressions	3	3	3	_____	_____
10/15	9 Equations with rational expressions	3	3	3	_____	_____
	8 Rules of exponents	10	8	4	_____	_____
10/22	10 Rational Exponents	6	3	3	_____	_____
10/24	12 Square Root Products and Sums	4	4	4	_____	_____
10/29	13 Completing the Square	4	4	4	_____	_____
10/31	11 Equations with Rational Exponents	4	4	4	_____	_____
11/5	15 Intersection and Inequalities	4	4	4	_____	_____
11/7	16 Conic Sections	5	5	-	_____	_____
11/12	16 Conic Sections	-	-	7	_____	_____
11/19	17 Exponential & Log Functions	-	8	-	_____	_____
11/21	17 Exponential & Log Functions	10	-	5	_____	_____
11/26	18 Exponential & Log Equations	5	5	5	_____	_____
12/3	19 Sequences	5	5	5	_____	_____
12/5	20 Binomial expansion	4	4	4	_____	_____

COMPUTER LAB FOR CALCULUS

The involvement of computers, especially computer graphics, in the calculus sequence opens many new possibilities for alternative teaching strategies. The following examples will indicate some of the possible directions.

Example 1: Plotting a function, determination of zeros, plotting the derivative, finding the critical points.

Program: Function plotter

Let y = (18*x - x*x - 4)/(x*x + 1)

-1 < x < 8 -6 < y < 6

a. Plot function using option 1.

b. Table of values.

c. Find zero of f(x).

d. Plot f'(x).

e. Find x value of critical point.

Example 2: Determination of limits of a function.

Program: Function plotter

Let y = sgn(1-x)*sin(x)

-3 < x < 3 -2 < y < 2

a. Plot function.

b. Determine limits left and right at x = 1.

Example 3: Polar coordinate graphs.

Program: Polar equation plotter

a. Plot sin(n*t) for n = 2, 3, 4, 5

b. Observe relation between n and number of "leaves"

c. Verify conjecture for n = 6, 7

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Example 4: Demonstration of the definite integral.

Programs: Riemann sums and Numerical integration

$$\int_0^3 (3*x - x*x)*sqr(x+1)\,dx$$

a. Load Riemann sum program and plot y.

$-1 < x < 3.5 \qquad -2 < y < 4$

b. Approximate area using norms .5, .2, .1

c. Load Numerical integration program and evaluate.

Example 5: Three dimensional graphs.

Program: Surface plotter, z = f(x,y)

Plot z = exp(-x*x-y*y)

$0 < x < 2 \qquad -2 < y < 2 \qquad 0 < z < 1$

Example 6: Determination of volume.

Program: Double integration

Evaluate:

$$\int_{-2}^{2} \int_{0}^{2} \exp(-x*x-y*y)\,dx\,dy$$

Compare with:

$$\int_{0}^{2} \int_{-2}^{2} \exp(-x*x-y*y)\,dy\,dx$$

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